

Public vs. private benefits: What drives willingness to pay for programmable heating thermostats?

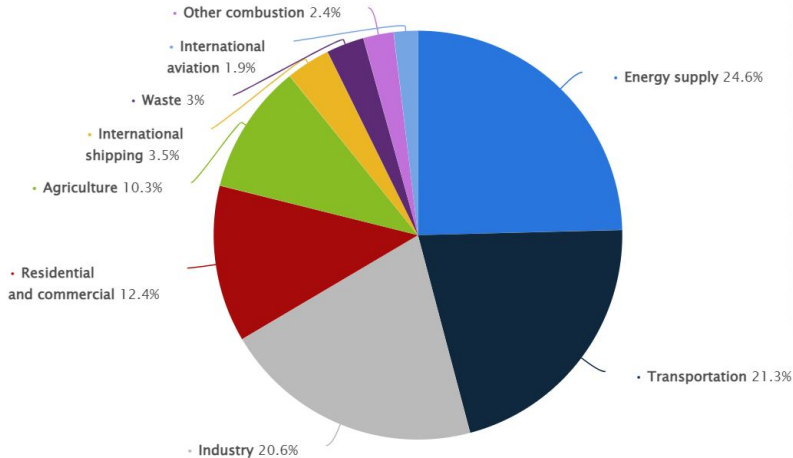
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EEA Rotterdam, August 27, 2024

- Pre-registered at AEA RCT Registry AEARCTR-0011637

Greenhouse gas emissions in the European Union, by sector



Note: Figures for 2021, Source:

<https://www.statista.com/statistics/1325132/ghg-emissions-shares-sector-european-union-eu/>

Programmable heating thermostats

- Digital devices offer new possibilities to conserve energy
 - through better demand management (Berger et al. 2022)
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→ **But:** Low adoption rates and thus seemingly low valuation!

Overview of this paper

Analyze a preregistered incentivized survey experiment with about 10,000 German households eliciting willingness to pay (WTP) for programmable heating thermostats with...

- ... randomized allocation to **“public good”** or **“private good”** information treatment or **“control”** group
- ...large set of further potential correlates

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Preview of findings

- “Public good” information significantly increases WTP by an average of almost €7
- No significant effect of “private good” treatment
- Some heterogeneity but no strong evidence that prior beliefs, technology openness or technical skills significantly influence households’ WTP

Understanding technology adoption

- Potential users are unfamiliar with associated cost, private and social benefits (Foster and Rosenzweig 2010)
- Information asymmetries often reason for low energy efficiency investments (Jaffe and Stavins 1994, Gerarden et al. 2017)
- Heterogeneous preferences for smart meter adoption (Pepermans 2014, Hmielowski et al. 2019 Mateus et al. 2023) → Informing households about cost and benefits of smart technologies may increase adoption rates

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 - Conflicting results on optimal messaging approaches: Make *environmental aspects* (Peters et al. 2018, Gosnell and McCoy 2023) or *economic aspects* (Berger et al. 2022) more salient
 - Unclear how to best promote pro-environmental/pro-social behavior: focus on self-interest (Allcott and Taubinsky 2015; Bollinger et al. 2020) or environmental information (Bolderdijk et al. 2012; Evans et al. 2012)

Research Question

- Is the low adoption rate of programmable heating thermostats a result of incomplete information?

My Contribution

- Improve understanding of households' valuation and determinants of digital technology adoption
- Add to existing, conflicting insights into effective messaging strategies aimed at energy-efficient behavior or investment decisions
- Additional focus on role of prior beliefs, technical skills, and technology openness as potential drivers or barriers to adoption

Data

- Experiment part of third survey wave of the German Heating and Housing Panel (GHHP) in May-June 2023
 - Survey designed by *RWI* and *PIK* and conducted by professional survey institute *forsa*
 - 15,000 households: 2/3 homeowners, 1/3 tenants
 - Elicitation of socio-economic and building characteristics, heating infrastructure, heating costs, environmental and psychological control variables
 - All participating households were eligible to participate in experiment: About **10,000 households opted into incentivized part**
 - Elicitation of WTP using a Multiple Price List (MPL) with choice between voucher ranging from €10 to €100 or thermostat

Summary Statistics

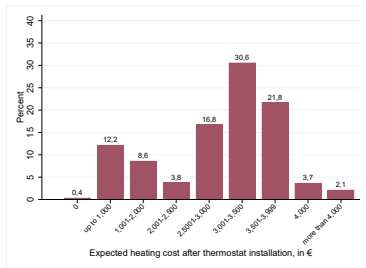
MPL

Experimental Groups

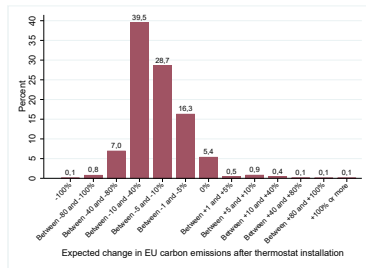
Control Group	Private Good Information Treatment Group	Public Good Information Treatment Group
<ul style="list-style-type: none">• General information about programmable heating thermostats	<ul style="list-style-type: none">• Control Group Information+ Information about potential annual energy and cost savings in percent: 9-14%, average of 10%+ Example calculation for 4-person household with absolute savings: Cost of 4000 Euros reduced by 400 to 3600	<ul style="list-style-type: none">• Control Group Information+ Information about heating-related emissions in Germany and emission reduction goals of EU+ Information about potential emission reductions in Europe if all households were equipped with programmable heating thermostats: 4.75%

Figure: Overview of Control and Treatment Groups.

Prior beliefs



(a) Expected heating cost



(b) Expected change in carbon emissions

Figure: Prior beliefs about potential heating cost changes and emission changes following the installation of programmable heating thermostats.

Interval regression of WTP on treatments

	(1)		(2)		(3)		(4)	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
Private good info	1.718	(2.256)	2.284	(2.200)	1.646	(2.164)	1.681	(2.143)
Public good info	6.721**	(2.290)	6.771**	(2.236)	6.852**	(2.193)	6.556**	(2.171)
Progr. thermostat=1	–	–	-20.853***	(2.062)	-22.732***	(2.050)	-19.451***	(2.140)
Constant	56.810***	(1.601)	-3.583	(20.929)	-5.888	(20.700)	-26.189	(20.953)
$\ln(\sigma)$	4.253***	(0.016)	4.225***	(0.016)	4.205***	(0.016)	4.193***	(0.016)
Socio-economic controls	No		Yes		Yes		Yes	
Building controls	No		No		Yes		Yes	
Further personal controls	No		No		No		Yes	
No. of observations	6641		6641		6641		6641	

Note: Robust standard errors in parentheses. ***, ** and * denote statistical significance at the 0.1 %, 1 % and 5 %, level, respectively.

Average WTP - Experimental Groups

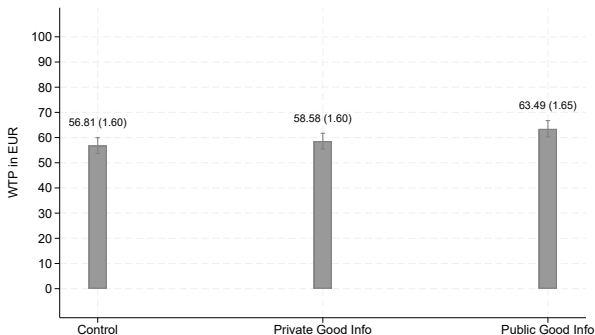
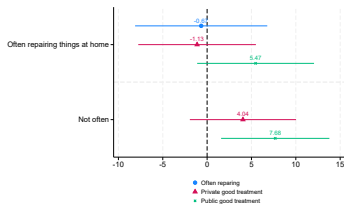


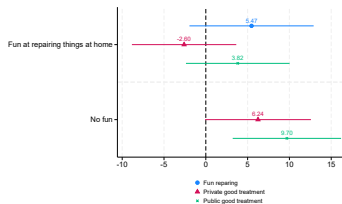
Figure: Mean predicted WTP per experimental group, based on interval regression model (1) without further covariates.

Number of observations = 6641

Heterogeneity I - Skills



(a) Often repairing



(b) Fun repairing

- No significant association of being “handy” with average WTP
- No evidence for stronger response to treatment

Heterogeneity II - Technology openness

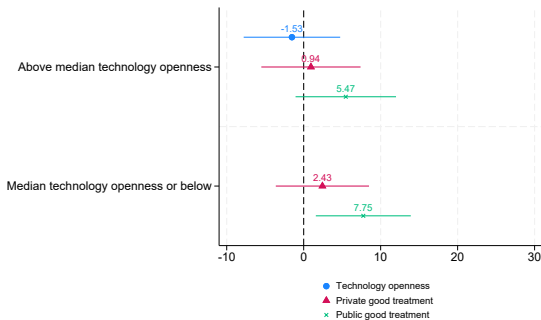
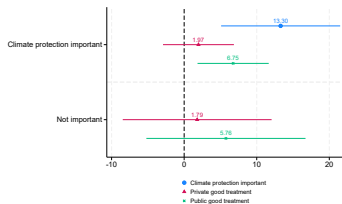


Figure: Technology hypothesis.

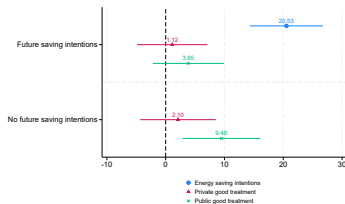
Number of observations = 6641

- No significant association of being open to new technologies with average WTP

Heterogeneity III



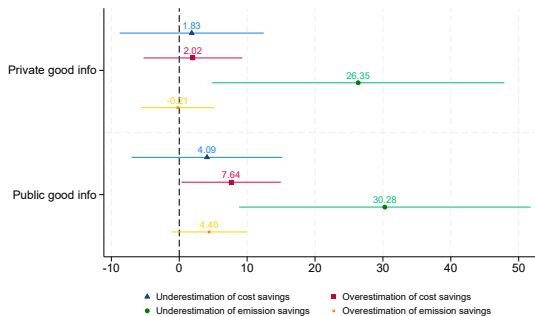
(a) Climate mitigation important



(b) Future saving intentions

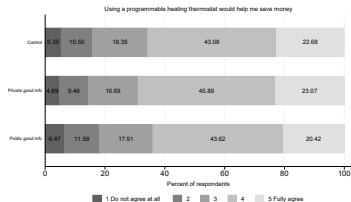
- Significant and increased treatment effect of public good information treatment for households who consider climate protection as important
- No significant treatment effect of private good information treatment for households intending to save energy in the future

Heterogeneity IV - Prior Beliefs

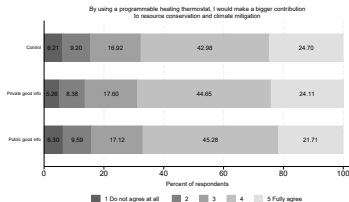


- Positive and significant effects of both treatments for households underestimating the emission reduction potential
- Positive and significant effect of public good info for households who overestimated cost savings

Approval with thermostat characteristics



(a) Money savings



(b) Resource conservation

- Agreement on statement on cost saving potential higher in private good treatment group
- Agreement on statement about resource conservation and climate mitigation lower in public good treatment group

Perceptions

Conclusions

- Stressing the private good feature of programmable heating thermostats increases WTP only for very few sub-groups
- Cost savings perceived as too high or not relevant (motivated reasoning)?
- No evidence that households with higher technology openness or technical skills respond more strongly to information
- Also minor role of prior beliefs for treatment response
- Making the public good feature more salient significantly increases households' WTP for programmable heating thermostats

Thank you! Questions or comments?
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Treatments

Text for everyone

As a reminder, a programmable radiator thermostat measures the room temperature and controls the radiator valve automatically - you no longer have to turn it. When you ventilate in winter, for example, it automatically regulates the heating down via a "window-open detection" with adjustable setback time. However, if it is too cold or too warm, you can also manually select a different temperature at any time.

On the programmable radiator thermostat, you can also set times for daily or weekly profiles at which heating should take place - for example, only in the morning before and in the evening after work. You can also set the exact temperature. Control can be done on the thermostat itself as well as via app. The programmable radiator thermostat is universally applicable and can be screwed onto all common radiators either directly or with the help of an adapter by unscrewing the old manual thermostat.

Treatments

Information on private good feature

We would now like to give you more information about programmable radiator thermostats. By installing programmable radiator thermostats in your apartment/house, you can save energy and thus heating costs. The exact savings potential depends on your previous heating and ventilation behavior as well as the age and renovation status of your building.

The consumer advice center assumes a savings potential of 9 to 14 percent per year if programmable heating thermostats are installed in all rooms, while Stiftung Warentest assumes a savings potential of around 10 percent per year for an average apartment in an older building.

If we assume that the aforementioned exemplary 4-person household lives in an average old building and has not previously used optimal heating and ventilation, it could reduce its annual heating costs by 10 percent from 4,000 euros to 3,600 euros. This corresponds to a reduction of 400 euros per year.

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Treatments

Information on public good feature

We would now like to give you more information about programmable radiator thermostats. Around 15% of energy-related emissions in Germany are caused by heating in private households.

With the EU climate law, the EU is aiming for an emission reduction of 55% for the year 2030 compared to 1990.

By installing programmable radiator thermostats, you can make an important contribution to this goal: According to current calculations, total CO₂ emissions in Europe could be reduced by 4.75% if all households in Europe were equipped with programmable thermostats in all rooms.

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Experimental Design

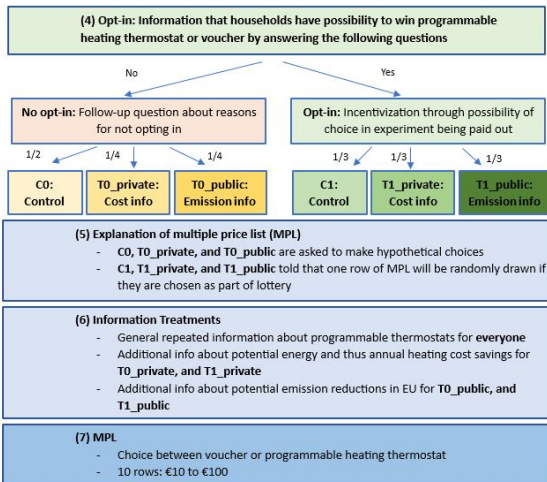


Table: Summary Statistics

	Mean	Std. Dev.	Min	Max
Homeowner	0.659	0.474	0.000	1.000
Household size	2.240	1.051	1.000	5.000
Female household head	0.406	0.491	0.000	1.000
Age	56.150	14.573	18.000	94.000
Monthly household net-income, in Euro	3,579	1,338	700	5,950
College degree	0.409	0.492	0.000	1.000
Urban	0.374	0.484	0.000	1.000
Building and heating characteristics				
Multi-family house	0.371	0.483	0.000	1.000
Floor area, in m^2	120.302	55.192	35.000	300.000
Built after 2002	0.166	0.373	0.000	1.000
Energy retrofit conducted since 2000	0.616	0.486	0.000	1.000
Gas heating	0.529	0.499	0.000	1.000
Oil heating	0.180	0.384	0.000	1.000
Heat pump	0.074	0.262	0.000	1.000
District heating	0.149	0.356	0.000	1.000
Other heating	0.068	0.251	0.000	1.000
Annual heating cost, in Euro	1,919	1,202	0.000	7,200
Manual radiator thermostat	0.563	0.496	0.000	1.000
Manual room thermostat	0.144	0.351	0.000	1.000
Digital/Programmable radiator thermostat	0.115	0.319	0.000	1.000
Digital/Programmable room thermostat	0.115	0.319	0.000	1.000
Other devices for heating control	0.054	0.226	0.000	1.000
No heating control	0.009	0.094	0.000	1.000
Digital thermostat is programmed	0.882	0.323	0.000	1.000

Table: Summary Statistics II

	Mean	Std. Dev.	Min	Max
Thermostat-related				
Informed about programmable heating thermostats	0.319	0.466	0.000	1.000
Exp. change in annual heating cost after installation, in %	-25.386	28.785	-99.000	126.150
Exp. change in EU CO2 emissions after installation, in %	-17.087	18.137	-100.000	100.000
Energy saving intentions in future	0.539	0.498	0.000	1.000
Technology and manual skills				
Technology openness	11.995	3.817	1.000	20.000
Data protection important with new technologies	0.754	0.431	0.000	1.000
Frequently repairing things at home	0.437	0.496	0.000	1.000
Fun at repairing things at home	0.499	0.500	0.000	1.000
Respondent responsible for repairing things at home	0.546	0.498	0.000	1.000
Manual skills required for job	0.119	0.324	0.000	1.000
Attitudes				
Rather left	0.259	0.438	0.000	1.000
Rather right	0.067	0.250	0.000	1.000
Value on NEP scale	21.492	4.013	0.000	30.000
Importance of climate protection	0.814	0.389	0.000	1.000
Willingness to take risks	4.535	2.055	0.000	10.000
Internal LOC	34.021	8.633	0.000	49.000

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Table: Balancing Experimental Groups

	Control	Private	Public	t-Stats3-2	t-Stats2-1	tStats3-1
Programmable thermostat	0.225	0.234	0.232	-0.153	0.877	0.724
Homeowner	0.663	0.651	0.663	1.046	-1.043	0.006
Household size	2.243	2.223	2.252	1.140	-0.792	0.348
Female household head	0.404	0.419	0.396	-2.004	1.305	-0.703
Age	56.307	55.939	56.203	0.763	-1.061	-0.299
Monthly net-income, in Euro	3,571.921	3,561.427	3,602.890	1.163	-0.297	0.872
College degree	0.405	0.407	0.415	0.599	0.251	0.851
Floor area, in m^2	120.932	118.904	121.067	1.651	-1.543	0.103
Built after 2002	0.171	0.158	0.171	1.429	-1.437	-0.013
Energy retrofit conducted since 2000	0.610	0.616	0.622	0.531	0.579	1.109
Gas heating	0.526	0.534	0.526	-0.711	0.700	-0.012
Oil heating	0.177	0.179	0.184	0.596	0.209	0.809
Heat pump	0.074	0.074	0.075	0.072	0.089	0.161
District heating	0.152	0.150	0.146	-0.442	-0.276	-0.716
Other heating	0.071	0.063	0.069	1.058	-1.413	-0.367
Informed program. thermostats	0.312	0.323	0.323	0.024	0.992	1.016
Exp. change heating cost, in %	-25.309	-25.761	-25.083	0.850	-0.568	0.282
Exp. change CO2 emissions, in %	-17.587	-16.949	-16.723	0.484	1.352	1.839
Future energy saving intentions	0.536	0.538	0.544	0.491	0.172	0.664
Technology openness	11.987	11.986	12.011	0.280	-0.017	0.263
Data protection important	0.760	0.755	0.747	-0.767	-0.448	-1.219
Frequently repairing things at home	0.440	0.427	0.443	1.273	-1.027	0.247
Fut at repairing things at home	0.493	0.494	0.509	1.270	0.081	1.353
Importance of climate protection	0.821	0.809	0.811	0.263	-1.310	-1.044
Rather left	0.269	0.252	0.257	0.485	-1.564	-1.082
Rather right	0.066	0.067	0.068	0.245	0.164	0.410
Willingness to take risks	0.338	0.326	0.338	1.042	-1.090	-0.048
Number of observations	3537	3518	3517			

Heterogeneity I

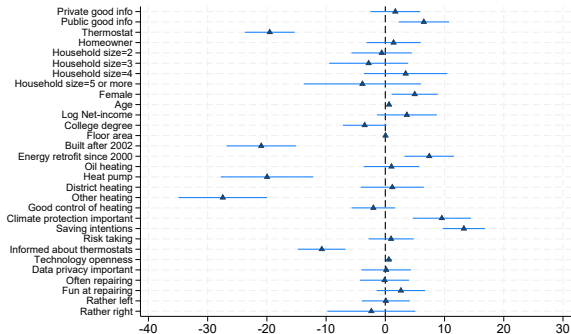


Figure: Correlation between WTP and different personal characteristics.

Heterogeneity II

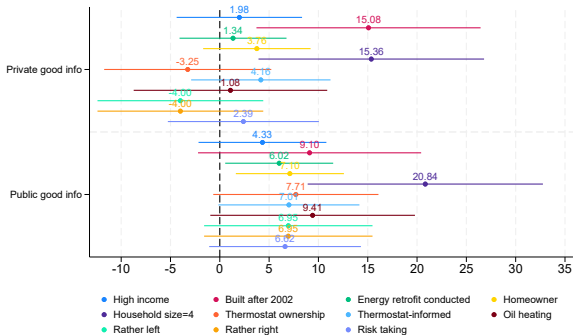
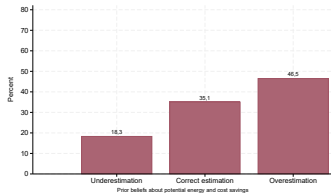


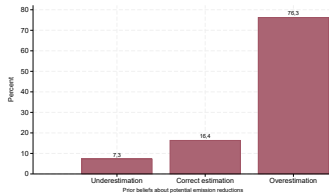
Figure: Heterogeneous treatment effects.

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Heterogeneity IV - Prior Beliefs I



(a) Prior belief about cost savings



(b) Prior belief about emission reductions

Figure: Difference between households' prior beliefs and actual information about private and public good features of programmable heating thermostats.

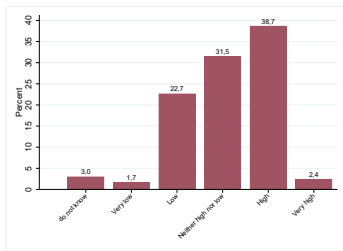
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Table: Interval regression to test for heterogeneous treatment effects w.r.t. prior beliefs with WTP as outcome variable

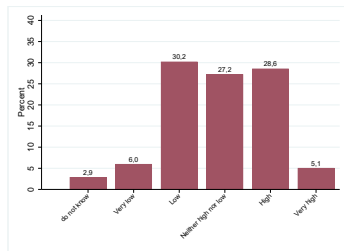
	Prior beliefs	
	Coeff.	Std. Err.
Private good info	5.575	(6.598)
Public good info	4.763	(6.678)
Underestimation of cost savings	-4.253	(4.663)
Overestimation of cost savings	-3.052	(3.853)
Underestimation of emission reductions	-32.645***	(8.502)
Overestimation of emission reductions	7.301	(4.402)
Private good info × Underestimation of cost savings	-1.159	(6.806)
Private good info × Overestimation of cost savings	-0.978	(5.371)
Public good info × Underestimation of cost savings	-1.407	(7.031)
Public info × Overestimation of cost savings	2.149	(5.457)
Private good info × Underestimation of emission reductions	21.441	(12.040)
Private good info × Overestimation of emission reductions	-5.127	(6.339)
Public info × Underestimation of emission reductions	24.803*	(12.057)
Public info × Overestimation of emission reductions	-1.079	(6.436)
Constant	55.855***	(4.663)
ln(σ)	4.173***	(0.018)
No. of observations		5009
Socio-economic controls		No
Building controls		No
Further determinants		No

Note: Robust standard errors in parentheses. ***, ** and * denote statistical significance at the 0.1 %, 1 % and 5 %, level, respectively.

Perception of presented benefits of thermostats



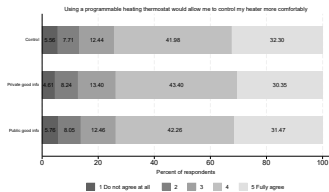
(a) Perception of potential cost savings



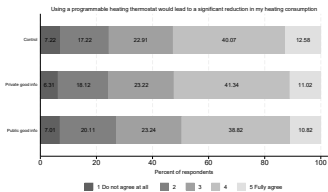
(b) Perception of potential emission reductions

Figure: Households' perceptions of provided benefits of programmable heating thermostats.

Approval with thermostat characteristics I



(a) Comfort



(b) Energy reduction

Figure: Approval with statements about programmable heating thermostats

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